

## Article

# Renewable Energy Consumption, Water Crises, and Environmental Degradation with Moderating Role of Governance: Dynamic Panel Analysis under Cross-Sectional Dependence

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**Abstract:** This study aims to investigate the relationship between renewable energy consumption, water availability, and environmental degradation with the moderating effect of governance in the South Asian region. This study collected data for renewable energy, water availability, governance, and environmental degradation for the period of 1988 to 2018 from the World Development Indicator. In panel data estimation, if cross-sectional dependence exists, it produces biased estimates. Therefore, this study applied a newly developed technique, dynamic common correlated effect, which produces efficient estimates in the presence of cross-sectional dependence. This study found that foreign direct investment positively and significantly increases environment degradation ( $\beta = 0.69^*$ , \* indicates the significance level at less than 1%) while renewable energy and water availability cause to reduce environment degradation ( $\beta = -0.08^{**}$ ,  $\beta = -0.09^{**}$ , \*\* indicates the significance level at less than 5%). Moreover, the study also found that governance significantly strengthens the relationship of renewable energy and water availability with environment degradation ( $\beta = 0.37^{**}$ ,  $\beta = 0.24^{**}$ ) while governance significantly weakens the relationship of foreign direct investment and environmental degradation ( $\beta = -0.34^*$ ). The study suggests that South Asian countries should improve political institutions, and promote renewable energy, water availability, and clean production to improve the environment quality.

**Keywords:** renewable energy consumption; water availability; foreign direct investment; institutional quality; environmental degradation

## 1. Introduction

During the last decade, researchers have shown considerable interest to explore the causes of climate change. Most of the literature proved that anthropogenic activities like land use, deforestation, industrialization, transportation, solid waste generation, and excess wastewater generation are responsible for the emission of greenhouse gases (GHGs). The emission of GHGs changes the climate and causes global temperature to rise [1]. According to the Intergovernmental Panel on Climate Change (IPCC) report, the highest emissions of GHGs were recorded from 2004 to 2014 [2]. Consequently, the concentration of poisonous gases like carbon dioxide (CO<sub>2</sub>), nitrogen (NO<sub>x</sub>), and methane (CH<sub>4</sub>) have increased by 80%, 20%, and 150%, respectively [3]. Moreover, CO<sub>2</sub>, NO<sub>x</sub>, and CH<sub>4</sub> are considered the

most poisonous GHGs and are largely accountable for climate change or environmental degradation [4]. Environment degradation is the depletion of resources like air, water, and soil. Many factors positively contribute to environmental degradation and the use of traditional energy is most prominent among them [5–7]. The production or consumption of conventional energy unexceptionally produces serious climate action like droughts, cyclones, desertification, etc. [8]. According to the report of Annual Energy Outlook, worldwide 42 pollutants of energy-intensified carbon releases are expected to rise to 35 million metric tons in 2020, and are likely to reach 44 billion tons in 2040 [9]. Therefore, researchers started to search for contemporary solutions to solve the problem of environmental degradation. Empirical research documented that the production and consumption of renewable energy significantly reduces the emission of GHGs, and is considered as an alternative to traditional energy consumption [10]. Moreover, Shafiei and Salim [11] argued that the renewable sources of energy such as “solar, wind, thermal, and hydro-power” not only significantly contribute to mitigating carbon dioxide emissions, but also compete for the increasing demands of sustainable energy, as they do not produce toxic gases and are regarded as environmentally friendly sources of energy [12]. However, some researchers contradict the argument and claim that volatile renewable energy (energy obtained from wind and solar) is not clean energy and tends to increase environmental degradation [13]. Therefore, there is a dire need to re-explore the renewable energy–environment nexus.

Similarly, foreign direct investment (FDI) is another important factor that contributes in environmental degradation [14,15]. Empirical literature showed mixed results related to FDI and environment degradation nexus. The first stance of the literature indicated the positive relationship between FDI and CO<sub>2</sub> emissions and claimed that FDI tends to increase GHGs by importing the contaminating technology into poor nations [16]. They further indicated that the foreign-invested industries have devoted most of their outflow to research and development which results in parallel emissions of GHGs inside the industry and vertical emissions among the industries [17].

On the contrary, researchers showed the negative relationship between FDI and CO<sub>2</sub> emissions and argued that FDI brings environmentally friendly technology which has a less significant contribution to carbon emission, to facilitate the production process [18]. Therefore, there is a need to re-examine the FDI–environment nexus

Water is another important factor that significantly contributes to environmental quality, as overexploitation of water resources causes environmental degradation while sustainable withdrawal causes balance in the environment. Therefore, inefficient land and water management destroys the natural ecosystem by reducing water resources, polluting water systems, and by increasing soil infertility and erosion [19]. Water is also an important source of renewable energy production [20]. Moreover, the scarcity of water is another challenge for developing nations as it increases water pollution all around the world which results in the deterioration of environmental quality. Unfortunately, authorities are continuously neglecting the issue of water crises (scarcity) which is an alarming situation and a serious threat to the country’s climate conditions [21]. Besides, the management of wastewater is another important issue that needs to be solved because if it is not managed properly it will lead to eutrophication. Therefore, the relationship between water availability–environment is needed to be explored empirically.

Governance is one of the most prominent factors that positively contributes to the relationship between renewable energy, FDI, water availability, and environmental degradation [22]. Governance makes the efficient utilization of foreign resources, i.e., by utilizing them for productivity, or efficient or sustained production processes [23]. It also makes continuous efforts to provide access of people to clean and fresh water [24,25]. The present study, therefore, assumes that governance strengthens or weakens the relationship between renewable energy, FDI, water availability, and environmental quality.

Recently, South Asian nations have observed rapid economic growth. The per capita growth rate of this region is 7.5% [26]. However, environmental degradation problems due to continuously extracting natural resources from the environment create an alarming situation in this region. Moreover, the entire population is exposed to dangerous problems of environmental degradation. Therefore,

there is a need to promote a sustainable environment in the region of South Asia, so environment sustainability becomes the main pillar in the framework of sustainable development goals (SDGs). Most of the SDGs are linked with environmental sustainability (shown in Table 1).

**Table 1.** Main pillars of environment sustainability and sustainable development goals (SDGs).

Main Pillars of Environment Sustainability	Link with SDGs
Environmental Protection	Goal 6: Clean Water and sanitation
	Goal 14: Life on Land
	Goal 15: Life below water
Low Carbon Emission	Goal 7: Affordable and clean water
	Goal 13: Climate action

Therefore, considering the importance of environmental sustainability, the question of “how to reduce environmental degradation” has encouraged many researchers to publish several empirical studies in various academic journals [27]. Although ample research is available that has examined the link between renewable energy and the environment quality [10,28,29], some studies found that the use of renewable energy causes degradation to the quality of the environment [29] while some documented that renewable energy consumption helps to improve the environment quality [30]. FDI–environment nexus is also a widely explored area but results are still controversial [31–33]. Besides, the studies of water and the environment are rarely reported in the existing literature [34,35]. However, no study so far has been conducted, specifically in the context of the South Asian nation, which has investigated the moderating impact of institutional quality on the relationship between renewable energy, FDI, water availability, and environmental quality.

Besides, one of the major problems with previous research is that governance is measured by a single indicator like corruption [36], law and order [37], or government stability [38]. All the indicators of governance are highly connected [39], and the utilization of a single indicator to measure institutional quality may be misleading and biased. Therefore, this study utilized an index of institutional quality computed by utilizing six variables like government effectiveness, political stability, voice and accountability, control of corruption, and regulatory quality. The overall index is to be calculated using principal component analysis. All these indicators possess the ability to affect the environmental quality and ecosystem of a country [40,41].

The present study is an attempt to extend the existing literature by investigating the moderating role of institutional quality on the association between renewable energy, FDI, water availability, and CO<sub>2</sub> emission and help the policymakers to develop the policies to control environmental degradation.

## 2. Literature Review

Hasnisah et al [42] utilized the data for 13 developing nations from 1980 to 2014 to examine the association between energy consumption and environmental quality and found that energy consumption was inversely related to the quality of the environment; as energy consumption increases, it will reduce the quality of the environment by increasing CO<sub>2</sub> emissions. Moreover, Solarin and Al-Mulali [43] examined the association between biomass energy consumption and environmental quality by utilizing the data of eight developed and developing countries for the period of 1980–2010 and found that an increase in biomass-energy consumption will reduce the quality of the environment; biomass energy consumption increased the CO<sub>2</sub> emission which in turn increased the environmental pollution and ultimately reduced the quality of the environment. Musibau and Mahmood [44] investigated the association between energy consumption and CO<sub>2</sub> emissions and established that as energy consumption increases it will cause an increase in the emission of CO<sub>2</sub> in the short run as well as in the long run. Besides, some studies found a causal relationship between energy consumption and CO<sub>2</sub> emissions and documented [45]. Salahuddin and Khan [46] also found the direct impact of energy

consumption on CO<sub>2</sub> emissions in Australia by utilizing the data from 1965–2007 and forecasted the association between renewable energy consumption and CO<sub>2</sub> emission. They concluded that the coming 10 years might be beneficial for the creation of a future energy policy for Australia. Halicioglu [47] used data from Turkey to investigate the impact of energy consumption on environmental quality and found that energy consumption negatively affected the environment quality, while Azlina and Law [48] also found a positive relationship between energy consumption and CO<sub>2</sub> emission by using the data throughout 1971–2009. Similarly, Shahbaz and Lean [49] also showed a direct association between energy consumption and CO<sub>2</sub> emissions.

Moreover, the literature revealed many studies that explore the association between renewable energy and carbon emission; specifically, Ito [50] used the data of 25 African countries and showed the positive relationship between renewable energy and environmental quality. Similarly, Zoundi [51] established, in the case of 12 MENA countries, a positive significant impact of renewable energy on environmental degradation. Awodumi and Adewuyi [52] investigated the association between biomass energy consumption and carbon emissions in Africa and showed a positive relationship between renewable energy consumption and CO<sub>2</sub> emissions.

Water is essential for human life, food, the environment, and economic growth. Socio-economic constancy is badly affected by lack of access to water. Pakistan is one of the most water-stressed countries on the globe. For socio-economic development and to support the needs of the new generation water would not be effectively accessible without appropriate precautions [53]. Pimentel and Cooperstein [54] investigated the impact of water deficiency on the quality of the environment and found that the environment quality was adversely affected by the deficiency of water. They also found that polluted water caused 90% of contagious diseases in underdeveloped countries. They suggested that the government should improve the quality of water.

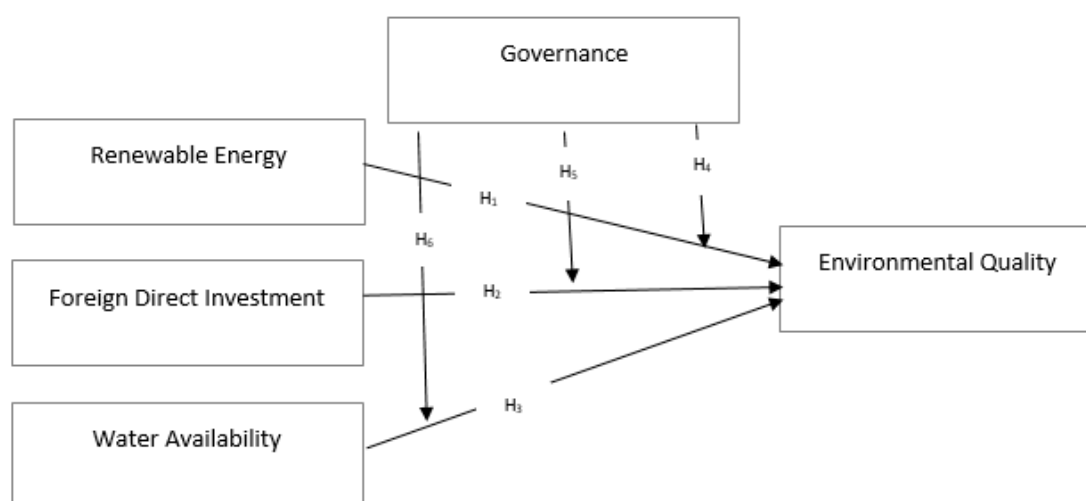
Akella and Saini [55] investigated the association between population density, FDI, income, export, import, and CO<sub>2</sub> emissions and found that FDI negatively affects environmental quality. The study used Johansen co-integration methodology in the case of Malaysia and concluded that the environmental Kuznets curve (EKC) holds for the sample. Hitam and Borhan [56] investigated the association between FDI and environment quality in Malaysia from 1965 to 2010 and the study found that environmental degradation was positively affected by the FDI.

Ahmad and Khan [57] investigated the role of FDI in environmental degradation by utilizing the data of 26 economies for the period 1998–2010 and established a positive association between FDI and environmental degradation. Lan and Kakinaka [58] probed the association between the inflow of FDI and the deterioration of the environment and human capital and found that in China FDI negatively affects environmental degradation, and Jiang, Zhou [59] concluded that overall FDI positively contributed to China's economy. Several studies have been conducted in Pakistan to study the relationship of FDI with CO<sub>2</sub> emission [60]. Bukhari, Shahzadi [61] investigated the association between FDI and economic growth, and deterioration of the environment in Pakistan. Data was collected from 1974–2010, the study utilized autoregressive distributed lag to investigate the association between FDI and CO<sub>2</sub> emission. The study confirmed that FDI causes damage to environmental quality.

Governance also plays an important role to save the environmental quality and plays an important role to strengthen the relationship among modeled variables, as all the proposed variables of the study are interlinked. However, the impact of institutional quality on environmental degradation is a less researched area [62]. Zakaria and Bibi [63] investigated the impact of financial development and governance on the environment in South Asia by utilizing panel data for the period of 1984–2015. The study found a negative association between governance and environment quality. Samimi [64] investigated the association between corruption and environment degradation by utilizing the data of MENA countries and North Africa over the period 2002–2007. The study found a negative association between corruption and environmental degradation. Therefore, a few studies investigated the impact of different governance indicators on the environment quality while no study utilized the index of six indicators for governance and no study investigated the moderating role of governance on the

relationship between renewable energy, FDI, water availability, and environmental degradation. So, the present study aims to fill the gap of existing literature by investigating the moderating role of governance on the relationship of modeled variables.

Environmental problems, like an increase in the levels of CO<sub>2</sub>, NO<sub>x</sub>, or CH<sub>4</sub>, are the main issue of concern for researchers and policymakers and need to be addressed on a priority basis. This study developed a theoretical/conceptual model (shown in Figure 1) by using the lens of core-macro economic theory [65], the theory of environmental governance [66], and the pollution halo hypothesis. These theories provide strong theoretical justifications for the relationship of renewable energy, FDI, and water availability with environmental quality [67]. Further, the governance or institutional quality plays a vital role to strengthen or weaken the relationship between renewable energy, FDI, and water availability with environmental sustainability. Core-macro economic theory justifies the relationship between renewable energy and environmental quality; this theory indicates that the consumption and production of energy from renewable sources (i.e., solar, hydropower, wind, thermal) are important for environmental sustainability and to reduce environmental problems (i.e., increased level of toxic releases such as CO<sub>2</sub>, NO<sub>x</sub>, CH<sub>4</sub>) [68]. The pollution halo hypothesis provides a theoretical lens on the relationship between FDI and environmental quality; it proposed that foreign control over the companies encourages the usage of cleaner processes of production which results in the reduction in poisonous GHGs. The hypothesis further states that the inflow of FDI in the domestic firm provokes the authorities to use new/upgraded or environment-friendly technology which significantly reduces GHGs emissions, and leads to an overall reduction in environmental degradation [69].



**Figure 1.** Conceptual/theoretical model of the study.

Environmental governance theory justifies the moderating role of governance on the relationship between renewable energy, water availability, FDI, and environmental degradation. The theory indicated that a strong regime (i.e., government) is needed to protect the environment [70]. The present study, thereby, proposes that the government of any nation make continuous efforts to protect the environment by organizing different rules of laws, and regulatory quality [71]. It also makes the efficient utilization of foreign resources, i.e., by utilizing them for productivity, or efficient or sustained production processes [72] and also makes continuous efforts to provide access to clean and fresh water to the people [24] to deal with serious environmental problems, i.e., increase in GHGs emissions. Therefore, the present study suggests that the above-mentioned theories could be useful lenses through which the underlying mechanism among modeled variables has been tested.

### 3. Data and Methodology

This study investigated the dynamic common correlated (DCCE) effect of renewable energy, FDI, and water availability on environmental degradation for South Asian countries. According to the availability of data, five South Asian nations are selected for empirical investigation: Pakistan, India, Bangladesh, Nepal, and Sri Lanka. The annual data for the period of 1988 to 2018 are collected from World Development Indicators (WDI). The description and measurement of variables have been explained in Table 2. Traditionally, researchers utilized Generalized Method of Movement GMM, and fixed and random effect models for estimation of panel data, but due to the problem of heterogeneity in panel data, these techniques produced biased estimators. The previous literature ignores the cross-sectional dependence in panel data which generates a problem of heterogeneity in the data which can produce biased estimators [73]. Therefore, researchers focused on the issue of cross-sectional dependence and used the dynamic common correlated effect (DCCE) technique to avoid spurious estimates [74].

**Table 2.** Description and measurement of variables.

Variables	Abbreviation Used	Definition/Measurement	Sources
Environment Degradation		Environmental degradation means depletion of natural resources like soil, air, and water, habitats destruction, ecosystem devastation, and pollution. This study utilized CO <sub>2</sub> metric tons per capita to measure environmental degradation.	World Development Indicators (WDI)
Renewable Energy Consumption	RNE	Renewable energy consumption is the share of renewable energy in total final energy consumption (% of total final energy consumption).	WDI
Water sources	WA	Billion cubic meters per capita.	WDI
Foreign direct investment	FDI	The inflow of foreign investment (% of GDP).	WDI
Institutional Quality		To measure institutional quality, the study will construct an index based on six variables that are government effectiveness, political stability, voice and accountability, control of corruption, and regulatory quality. The overall index is be calculated by using principal component analysis.	WDI
Trade Openness	TOP	Import of goods and services (% of GDP) + export of goods and services (% of GDP)/GDP (annual %).	WDI



Table 2. Cont.

Variables	Abbreviation Used	Definition/Measurement	Sources
Financial Development	FD	To measure financial development, the study will construct an index based on three variables, including liquid liabilities (% of GDP), money supply (% of GDP), and domestic private credit to the banking sector (% of GDP). The overall index is calculated by using principal component analysis.	WDI
Governance	GOV	To measure governance, this study constructs an index based on six variables like government effectiveness, political stability, voice and accountability, control of corruption, and regulatory quality. The overall index is be calculated by using principal component analysis.	WDI

The DCCE approach is developed by utilizing the pooled mean group (PMG) technique that was developed by Pesaran, Shin [75]. The DCCE approach resolves the issues of cross-sectional dependence by taking logs and averages of cross-sectional units. Besides, DCCE techniques adjust heterogeneous slopes and dynamic common correlated effects and produce reliable estimates in case of small sample size by applying the method of jackknife correction [76]. Furthermore, the DCCE technique also produces unbiased estimators when panel data is unbalanced [77] and has structural breaks [78].

Besides, along with the selected South Asian nations, this study investigates the cross-sectional dependence (CD) in each variable by using the Pesaran dependency test. The results of the CD test reported in Table 1 show the issue of cross-sectional dependence exists in variables. So, the findings prevent us from using the first-generation unit-root test because all the variables have suffered from the problem of cross-sectional dependency.

Therefore, this present study determines the stationarity of variables by using the Pesaran [79] second-generation unit-root (CIPS) test. For the estimation of long-run results, this study used Westerlund and Edgerton [80] co-integration technique because it incorporated a short time dimension and structural breaks.

#### Model Specification

The study uses the following econometric model to investigate the impact of renewable energy consumption, water availability, and foreign direct investment on environmental degradation:

$$CO_2 = \beta_0 + \beta_1 RNE + \beta_2 WA + \beta_3 FDI + \alpha_1 TOP + \alpha_2 FD + \pi_0 GOV + \pi_1 RNE \times GOV + \pi_2 WA \times GOV + \pi_3 FDI \times GOV + \mu_3 \quad (1)$$

In the above equations, the coefficients shown by  $\beta$  depict the slope of an independent variable. Coefficients of  $\alpha$  depict the slope of the control variable. Coefficients of  $\pi$  depict the slope of the moderating variable. Where RNE = renewable energy; WA = water availability; FDI = foreign direct investment; TOP = trade openness; FD = financial development; GOV = governance.

$$CO_2 = \alpha_i CO_{2it-1} + \eta_i X_{it} + \sum_{p=0}^{pr} \lambda_{xip} X_{it-p} + \sum_{p=0}^{pr} \lambda_{yip} X_{it-p} + \mu \quad (2)$$

In this equation,  $CO_2$  shows environment degradation and the lag value of  $CO_2$  ( $CO_{2it-1}$ ) is used as an independent variable while  $X_{it}$  indicates the set of independent variables like renewable energy consumption, WA, FDI, financial development, and trade openness.

#### 4. Results and Discussion

The study empirically analyzes the association of renewable energy, water resources, and FDI on environment degradation in the South Asia region (India, Nepal, Pakistan, Bangladesh, and Sri-Lanka). According to the unavailability of data, other South Asian nations are not incorporated in the study. The data for the period of 1988 to 2018 are collected from WDI.

##### 4.1. Preliminary Findings

Table 3 demonstrates the findings of descriptive statistics and correlations among all seven modeled variables. This table shows the mean, median, maxima, minima, and standard deviation of data; furthermore, it also shows skewness and kurtosis along with maximum and minimum values of the data. The normality of residuals has also been checked through the Jarque–Bera test. Due to the problem of cross-sectional data, the null hypothesis is that residuals are normal, so as we can see that all the probability values are greater than 5% level of significance; so, this study accepts the null hypothesis.

**Table 3.** Descriptive statistics.

	CO <sub>2</sub>	FDI	RNE	WA	GOV	FD	TOP
Mean	0.662	0.845	61.577	173.562	0.042	86.591	9.494
Median	0.590	0.691	57.604	23.913	−0.184	28.875	8.753
Maximum	3.028	3.668	96.078	1663.82	1.798	345.55	22.54
Minimum	0.033	−0.098	34.747	0.735	−1.980	11.786	3.072
Std. Dev.	0.581	0.743	17.364	257.77	1.000	111.87	4.417
Skewness	1.833	1.293	0.529	1.06	0.111	1.47	0.633
Kurtosis	7.226	5.202	2.128	9.016	1.626	3.294	2.961
Jarque–Bera	2.209	3.552	2.165	3.4563	2.503	5.7162	0.3772
Probability	0.41	0.15	0.38	0.11	0.29	0.07	0.56
CO <sub>2</sub>	1						
FDI	0.50	1					
RNE	−0.49	−0.49	1				
WA	0.45	0.27	−0.49	1			
GOV	−0.35	−0.04	0.14	−0.50	1		
FD	0.43	0.25	−0.47	0.48	−0.49	1	
TOP	−0.11	0.19	0.43	−0.17	0.18	−0.11	1

The results of correlation which is used to check the multi-co-linearity in the data indicate that the correlation value among all modeled variables is less than 0.50; so, there is non-multi collinearity among the variables.

Due to the nature of panel data, the problem of cross-sectional may occur; so, this study investigates the cross-section dependency in the variable by using the Pesaran [81] dependency test, and findings are reported in Table 4. Results indicate that cross-sectional dependence exists in variables; so, this is unable to utilize the first-generation unit root test. The results of the CIPS are reported in Table 5. Results indicated that renewable energy (RNE), financial development (FD), trade openness (TOP), and growth (GDP) are stationary at the first difference and integrated at I(1), but have the problem of unit root at the level. However, environmental degradation ( $CO_2$ ), water resources (WA), and institutional quality are stationary at the level.



**Table 4.** Cross-section dependence test results.

Variables	CD Test	p-Value
CO <sub>2</sub>	13.65 *	0.00
FDI	5.39 *	0.00
RNE	13.90 *	0.00
WA	9.32 *	0.00
GOV	2.95 *	0.00
FD	5.53 *	0.00
TOP	8.86 *	0.00

Note: \* refers to the rejection of the null hypothesis of no cross-sectional dependence (CD) at less than 1% level of significance.

**Table 5.** Second-generation unit root test (CIPS).

Variables	Level	First Difference
CO <sub>2</sub>	−4.04 *	−
FDI	0.27	−7.00 *
RNE	−4.10 *	−
WA	−2.32 *	−
GOV	−1.09	−8.55 *
FD	0.87	−6.43 *
TOP	0.76	−5.90 *

Note: \* refers to significance at less than 1% respectively.

#### 4.2. Long Run Empirics

In Table 6, Westerlund and Edgerton [80] co-integration technique was used for the estimation of long-run results, which confirms the long run presence of renewable energy, FDI, water availability, financial development, growth, trade openness, and institutional quality. The probability values of Westerlund and Edgerton [80], Gt, Ga, P0, and Pa are less than 0.05 which shows that long-run co-integration exists among variables, so, the study rejects the null hypothesis of no co-integration.

**Table 6.** Westerlund ECM (Error Correction Model) panel co-integration tests.

H0: No Co-Integration	Value	p-Value
Gt	−4.09 *	0.000
Ga	−12.81 *	0.000
P0	−9.65 *	0.000
Pa	−8.98 *	0.000

Note: \* refers to the level of significance of less than 1%.

The results of DCCE are present in Table 7, which indicates that renewable energy and water availability significantly and negatively affect environmental degradation ( $\beta = -0.086$  \*;  $\beta = -0.09$  \*); this means that as consumption of renewable energy and water availability increase, environment quality will improve. However, governance affects environmental degradation more ( $\beta = -0.11$ ) as compared to renewable energy (0.086 \*) and water availability ( $\beta = -0.09$ ). Moreover, there is a positive and significant association between FDI and environmental degradation ( $\beta = 0.69$ ).

The findings of this study suggest that the consumption of renewable energy improves the quality of the environment. The findings of this study support the recent environmental policies that are proposed in Kyoto Protocol arrangements and the Intergovernmental Panel on Climate Change (IPCC) [82]. Our findings are consistent with Apergis and Payne [83], Shahbaz, Mutascu [84], and Jebli, Youssef [30]. The negative association of renewable energy consumption and environmental degradation indicates that renewable energy consumption causes a reduction of CO<sub>2</sub> emissions and ensures an eco-friendly environment. In Pakistan consumption of fossil fuels is very high because of the rising population which affects the environment adversely, so the Federal Ministry of Environment

is trying to mitigate these climate change impacts by implementing a renewable energy program [85], which helps to find sources of and funding for renewable energy consumption. The results of DCCE confirmed the relationship between renewable energy consumption and environmental degradation and agreed with the energy-consumption-environment-led hypothesis. Besides, a negative relationship between water availability and environmental degradation emphasized that as water availability decreases, environmental degradation increases. Results are consistent with existing studies by Qi and Luo [86] and Majeed and Luni [87]. As Pakistan is a populous country and heavily dependent on the agriculture sector which places immense pressure on available limited water resources, intensive exploitation of water resources to meet the demand of rising population and agriculture activities causes a sharp decrease in water resources and severe deterioration of the water environment. Inadequate water resources affect environment quality by increasing dust due to dryness and reducing the ability of soil to support crops and plants.

**Table 7.** Results of dynamic common correlated effects (DCCE) estimation.

IV	$\beta$	<i>p</i> -Value
CO <sub>2</sub> (−1)	−0.09 **	0.02
FDI	0.69 *	0.00
RNE	−0.08 **	0.02
WA	−0.09 **	0.01
GOV	−0.11 *	0.00
FD	0.67 **	0.04
TOP	0.05 **	0.05
RNE * GOV	0.37 **	0.05
WA * GOV	0.24 **	0.02
FDI * GOV	−0.34 *	0.00

Note: \* and \*\* indicate significance at less than 1% and 5%, respectively.

Moreover, results indicate that FDI has a positive and significant relationship with environmental degradation; as FDI inflow increases, it will cause degradation to the environment quality. Our results are consistent with Zhou, Fu [88], and contradict with Atici [89] and Kirkulak, Qiu [90]. The finding of this study is justified as Pakistan is a developing country, so at the initial stage of development, the host country provides favorable opportunities like relaxation in taxes and environmental standards to attract more funds and investment. Resultantly, increased FDI leads to industrialization that provides acceleration to the economy and increases the consumption of traditional energy which is the main driver of environmental problems. Therefore, in the case of Pakistan, the initial effect of FDI on CO<sub>2</sub> emission is positive and supports the pollution haven hypothesis sufficiently.

This study also investigated the moderating role of governance on the relationship between renewable energy consumption, water availability, and FDI with environmental degradation. A study found that governance significantly strengthens the relationship between renewable energy consumption and environmental degradation ( $\beta = 0.37$ ), water availability and environmental degradation ( $\beta = 0.24$ ), while the findings of the study suggest that governance significantly weakens the undesired positive relationship between FDI and environmental degradation ( $\beta = -0.34$ ). Moreover, the findings of the study suggest that the desired negative relationship between renewable energy consumption and environmental degradation will strengthen in the presence of good governance. Good governance help to meet the environmental challenges particularly related to climate change, which is associated with large inflow flows of funds [91]. The large inflow of flows of financial resources can create conditions prone to environmental degradation. Good governance is acknowledged as an important factor to mitigate the undesired impacts of FDI [92].

Besides, integrating renewable energy sources such as solar energy, biomass energy, geothermal energy, wind energy, and hydropower into the agricultural and industrial production process is also very critical, so governance can play an important role to strengthen the negative association between renewable energy and environmental degradation.

## 5. Conclusions and Implications

This study investigated the role of renewable energy consumption, water availability, and FDI with controlling variable likes trade openness, financial development in environmental degradation in South Asian countries. Moreover, this study has investigated the moderating role of governance between renewable energy consumption, water availability, FDI, and environmental degradation. The study found that energy consumption and water availability significantly lower the emissions of CO<sub>2</sub> and reduce environmental degradation. However, FDI significantly increases environmental degradation in South Asian countries. Thus, the study established that good governance strengthens the association of renewable energy consumption and water availability with environmental degradation while good governance also plays a significant role to weaken the undesired positive association between FDI and environmental degradation.

Based on the above conclusion, this study draws many policy implications for South Asian countries. First, to avoid environmental degradation, South Asian nations must adopt energy efficiency policies and policies to increase the sources and utilization of renewable energy consumption.

Although due to tropical, humid climatic conditions, South Asian countries are continuously exploring the opportunities like solar, wind, hydro, and biomass for renewable energy, there is a large gap between the potential of fossil fuel supply and the energy demand to achieve the South Asian countries' new social and economic development targets for 2020 set by their central governments [93]. Therefore, to meet the SDGs of environmental sustainability, national and international energy policies should be devised with great effort to fully utilize renewable energy sources and develop more collaboration between public and private stakeholders to achieve set targets. Moreover, clean energy provision also attracts FDI and helps to achieve Millennium Development Goals (MDGs) like reduction in poverty and sustainable economic growth.

Second, the study suggests that water and management authorities should produce and distribute water resources in a scientific manner so a certain level of availability of water can be ensured. Besides, the government should design the water-conserving strategies and redesign the water distribution system to satisfy maximum water demand and to protect environmental quality. Moreover, to maintain a certain level of availability of water resources, water management authorities should stop the depletion of water by implementing some rational irrigation taxes and adopting marketing management mechanisms, to create awareness about saving water and protecting the environment.

Third, to attract FDI from a technically advanced nation, developing nations must encourage policies for adaptation of environment-friendly technology that helps to reduce carbon dioxide emissions. Further, the South Asian nations should strengthen their institutions so they can effectively design and implement environmental protection policies and can promote a green economy in the future.

Fourth, the traditional wastewater treatment process would produce a large amount of sludge and CO<sub>2</sub> emissions, so the government should promote algal photosynthesis because it would significantly decrease the CO<sub>2</sub> emissions and energy cost. Moreover, food waste should be turned to fertilizers to support sustainable water reengineering.

Fifth, modern methods for wastewater treatment like innovative microalgal-bacterial granular sludge process should be adopted to reduce GHGs emissions. It has been reported that 92.69%, 96.84%, and 87.16% of influent organics, ammonia, and phosphorus, respectively, could be removed in this process [94].

The present study has some limitations; first, the present study is conducted on selected South Asian economies. Future researchers can conduct a replica of the study in the context of different emerging and developing economies. Second, the present study uses CO<sub>2</sub> as a proxy of environmental degradation, future researchers can use different proxies i.e., Nox, ecological footprints, so future researchers can also create an index by using different environmental proxies to get more authentic and precise results.

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